PowerWorks 250- kWe Microturbine

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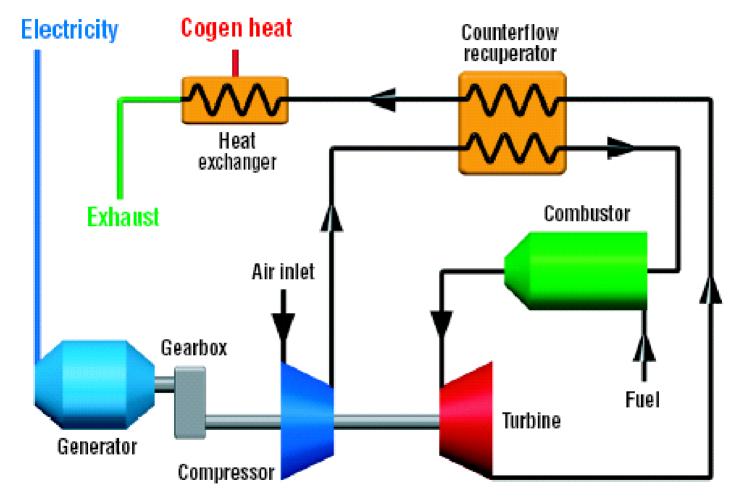
250kW Development – Overview

Scope:

- 250kW Microturbine Generator
- Scale-down IR KG2 Engine
- Synchronous; Dual-Mode
- Indoor and Outdoor
- Alternate Fuels
- Range of Cogen Options
- 32% target efficiency
- <9 ppm Nox
- 72 dBA (1m) Sound Level



The PowerWorks Engine Cycle





IR Frame 4 -250 kWe Microturbine

- Rated ISO conditions
 - Power = 250 kWe
 - Pressure ratio = 4.1
 - Mass flow rate = 1.84 kg/s
 - -TIT = 927 C (1700 F)



250kW - Prototype Build & Testing

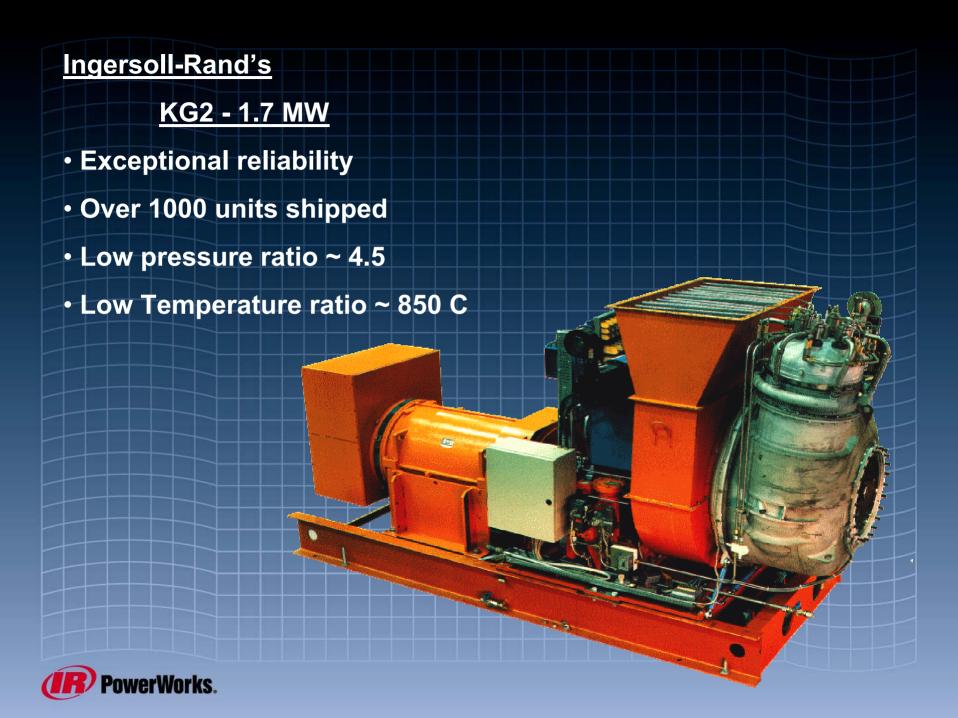
Prototype P1: First Full Prototype

- Started Oct-2002; Ongoing
- Mech Checkout; Ventilation
- Controls Development

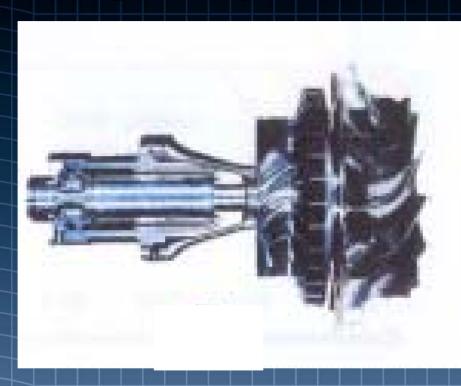




Prototype P2:



The Legendary KG2 Rotor system



Simplicity

- Cantilevered radial turbine and compressor
- •cool-end bearings and drive

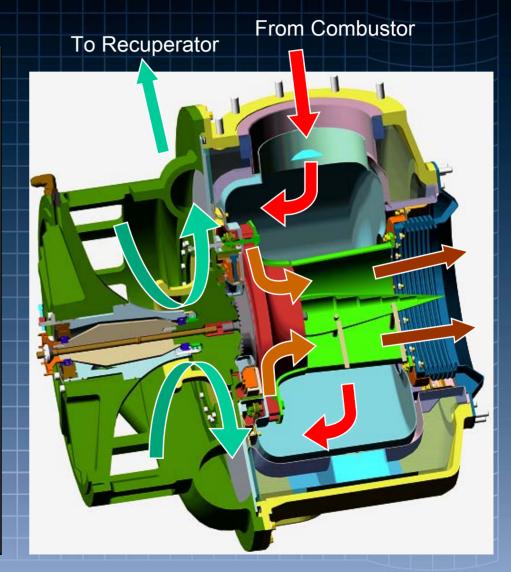


Reliability

- •Proven over 30 years and 1000 units
- •One unit has 120,000 hours without over-haul

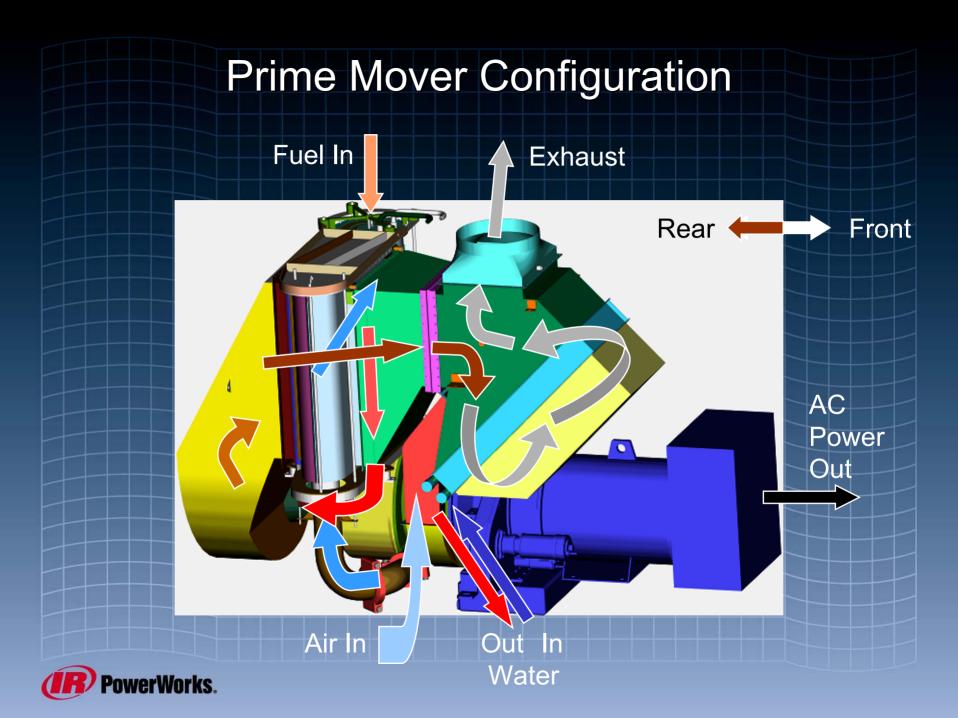
Engine Core Configuration

- Draws From Rugged KG2 Design
 - Overhung, back to back rotating components
 - All bearings in cold end
- 45,000 rpm
- Radial compressor and turbine
 - Vaned compressor diffuser
 - Turbine nozzle guide vanes
- 80,000 component life
- Up to 3,500 cold cycles
- Up to 20,000 hot cycles





Combustor integral with recuperator - Eliminates combustor transition parts Swirler head **Combustion Liner**



Applications Customer Power Power Environ. **Cost Savings Power Quality Motivations** Compliance Generation **Availability** Typical Agriculture, Health Care. Landfill, Communication, Petroleum, Application Hotel. Universities, Mining, IT, Process. Segments **Hi-Value Mfg** Chemical Food Distrib. Wastewater **Materials** Type of Service Cogeneration **Peak Shaving Prime Power Running Backup Remote Power**



Codes Used in Development

• UL 2200	Stationary Engine Generator Assemblies
• NFPA 37	Stationary Combustion Engines
• NFPA 54	National Fuel Gas Code
• NFPA 70	National Electric Code
• EGSA	Safety Codes Required by States & Major Cities
ANSI / NSF 51	Standard for Food Equipment
• ANSI C84.1	Electric Power Systems & Equipment Voltage Ratings
(60Hz)	
• ANSI 133.8	Gas Turbine Installation Sound Emissions
• ANSI 133.9	Measurement of Exhaust Emissions From
	Stationary Gas Turbine Engines
• ANSI B133.10	Gas Turbine Information to be Supplied by User
	and Manufacturer
• EPA Section 1417	Safe Drinking and Water Act
• CSA C22.2 #100	Motors and Generators, Industrial Products
· OSHA 1910.95	Occupational Noise Exposure
.101	Compressed Gases
.144	Safety Color Codes for Physical Hazards
.145	Signs and Tags
.146	Permit Required Confined Spaces
.147	Control of Hazardous Energy



Other Codes That Can Apply

- UL1741 Power Converters / Inverters, plus utility interfacing for interconnect protection
- Existing Electrical Interconnect Standards
 - NY: PSC Standardized Interconnect Requirements ...
 - CA: Rule 21
 - Future? IEEE SCC21 P1547 National Interconnect
- Major building codes :
 - National Building Code
 - Uniform Building Code
 - Standard Building Code
- Geographic-specific codes:
 - New York State Uniform Fire Prevention and Building Code Title
 9B NYCRR
- US EPA, State, and Local Emissions Requirements



250kW PowerWorks Specifications



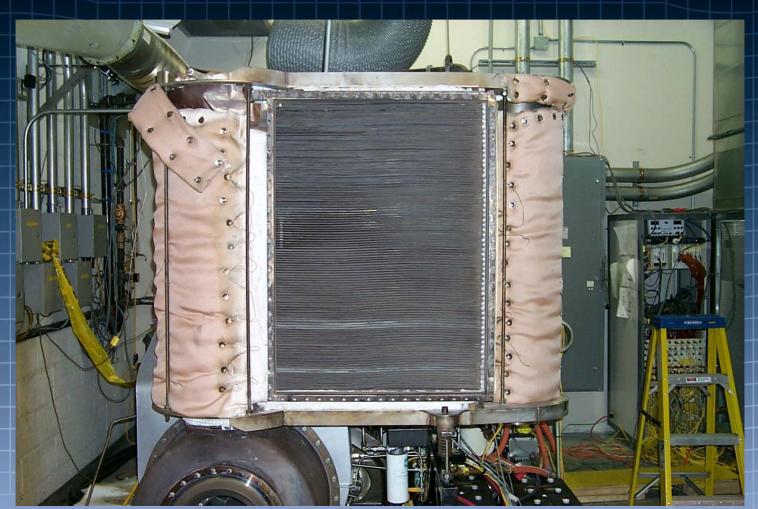
Physical

	LxWxH	Weight
Base	126 x 76 x 89.5 in	9000 lb
System	320 x 193 x 227 cm	2200 kg
Paralleling	24 x 32 x 78 in	650 lb
Switchgear*	61 x 81 x 198 cm	295 kg

^{*} Optional equipment



250-kWe Recuperator / Combustor Integration Design proven in 70-kWe PowerWorks





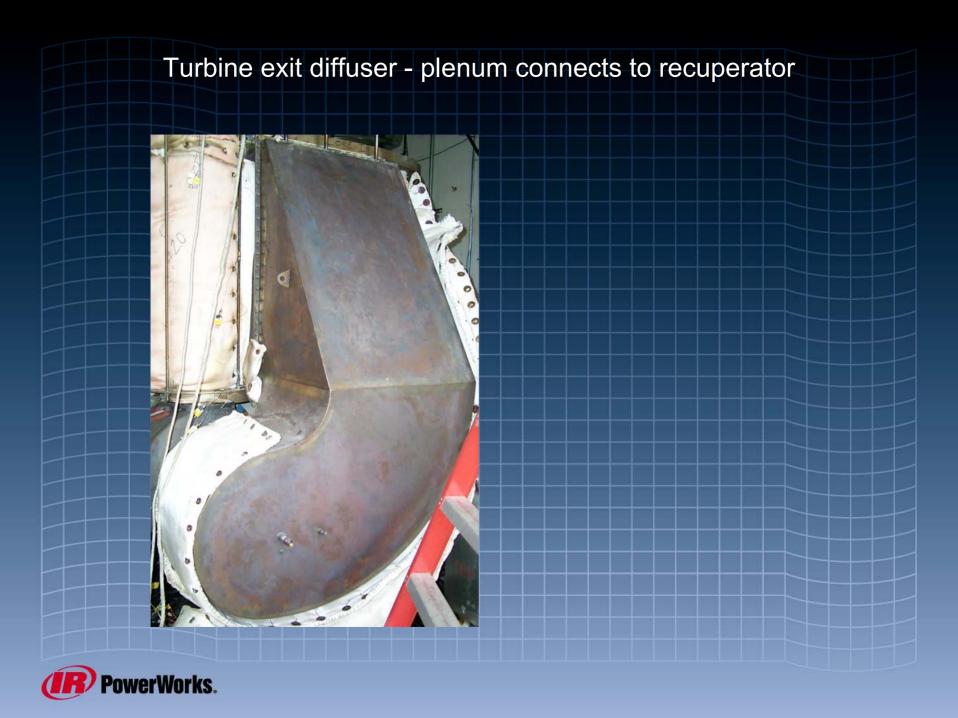
PowerWorks F4 Combustor liner

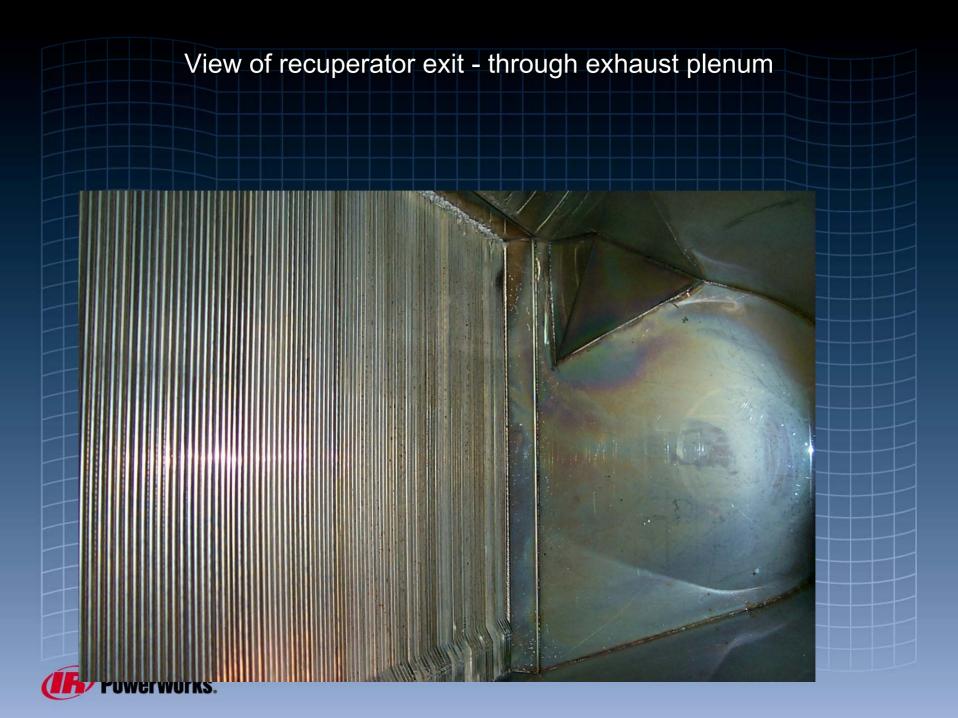




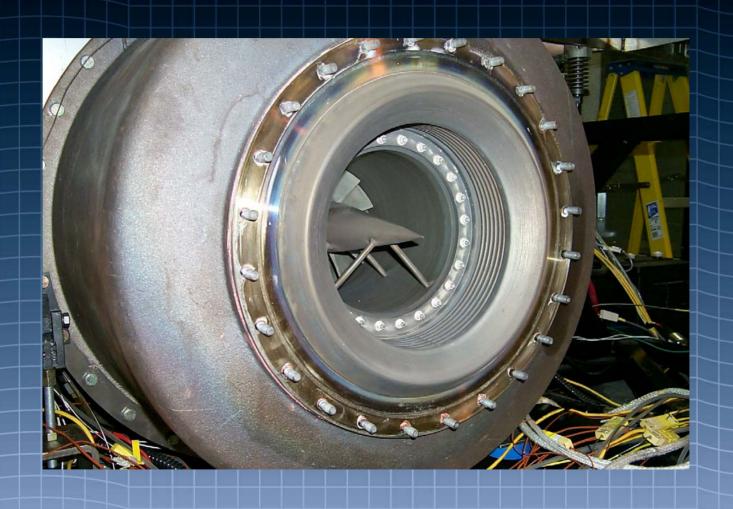
NOx and CO below 9 ppmv at 15%O2 Full Load







Turbine Casing





Recuperator effectiveness

(mC _p ∆T) _H /(mC _p ∆T) _C based on all T/C's	(mC _p ∆T) _H /(mC _p ∆T) _C based on inferred Tcomb-inlet and turbine exit T	$\epsilon_{\rm HX}$ based on all T/C's - $\Delta {\rm T}_{\rm air\; side}$ / $\Delta {\rm T}_{\rm ideal}$	ϵ_{HX} air side based on inferred $T_{comb-inlet}$ and turbine exit T - ΔT_{air} side $/\Delta T_{ideal}$
103.5%	102.8%	92.1%	92.8%
103.8%	105.4%	91.8%	90.5%
103.9%	105.6%	91.7%	90.3%
104.4%	106.5%	91.5%	89.7%
105.3%	105.8%	90.6%	90.2%
104.7%	104.9%	91.1%	90.9%
103.7%	105.0%	91.8%	90.8%
103.2%	104.5%	92.1%	91.1%



Projected Power and Efficiency

